TECHNICAL MEMORANDA NOS. 1 AND 2

REVIEW OF PREVIOUS STUDIES, WATERSHED IMPROVEMENT PROJECTS, AND GIS COVERAGES

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1.0 INTRODUCTION

This document provides a summary of previous studies, watershed improvement projects, and geographic information systems (GIS) coverages in the Panoche/Silver Creek Watershed (PSCW), as required in the work plan associated with CALFED grant project 2000-E02 (Westside Resource Conservation District [WRCD], 2000). The purpose of this document is to provide objective and unbiased summaries, but not critique, of previous studies, reports, and available data. Two separate technical memoranda were specified in the work plan. These memoranda were intended to provide a summary of: the 1998 study by the U.S. Bureau of Reclamation (BOR), U.S. Geological Survey (USGS) selenium concentration data collected from Panoche Creek at Interstate-5, selenium source characterization information, and previously applied watershed improvement projects (Technical Memorandum 1); and GIS coverages of land ownership/land use and other existing and planned GIS data (Technical Memorandum 2). Technical Memoranda 1 and 2 are combined in this document, which provides information to meet the objectives of these two technical memoranda. In addition, a listing of references related to the PSCW and surrounding area is provided in Appendix B; the listing is an update of the NRCS <u>Panoche-Silver Creek Literature Review and Technical Summary</u> (NRCS, 1997).

The objectives of this document (Technical Memoranda 1 and 2) are to:

(1) Identify and summarize previous studies and data that could be relevant to characterization of sediment and selenium sources in the PCSW upstream of Interstate-5 (I-5);

(2) Identify and summarize previous watershed improvement projects implemented in the PSCW upstream of I-5; and

(3) Summarize GIS coverages that exist or are planned for future development.

Figure 1 is provided to show the general location of the PSCW and major physiographic features. Previous studies and watershed improvement projects have been conducted in areas upstream and downstream from Interstate-5 (I-5) with some focus on lands upstream of I-5. Most of the watershed improvement projects upstream of I-5 were related to range management and were implemented on lands owned by the U.S. Bureau of Land Management (BLM). Improvement projects downstream of I-5 have focused on improvement of channel bank stability in several reaches and were implemented on privately owned lands.

The following four major studies were completed in 1998, 1999, and 2001 under four independent funding sources, and are summarized in this document in Sections 2.0, 3.0, 4.0, and 5.0, respectively: the "1998 Sedimentation Study" which focused on the PSCW upstream of the California Aqueduct (MFG, 1998); the "Floodplain Corridor Study" which focused on the area from I-5 downstream to the Fresno Slough (North State Resources et al., 1999); the "Summers Report" (Summers Engineering, 1998) which provided a summary of hydrology, flood damages, and potential remedies in the PSCW downstream from I-5; and the "Benefits Analysis" (MFG, 2001) which provided an evaluation of ecosystem and economic benefits associated with sediment and erosion control BMPs. Additional studies that are relevant to the objectives of this document are summarized in Section 6.0.

Previous watershed improvement projects implemented in the PSCW upstream of I-5 are summarized in Section 7.0. Available and planned geographic information system data coverages in the PSCW are summarized in Section 8.0.

2.0 THE 1998 SEDIMENTATION STUDY

The 1998 Sedimentation Study focused on the PSCW upstream of the California Aqueduct (MFG, 1998), and provided a general characterization of sediment sources in upland and/or streambank areas in the PSCW. A more detailed analysis was provided for: (1) the upland areas surrounding the confluence of Panoche and Silver Creeks; and (2) the Panoche Creek channel from the confluence area downstream to the California Aqueduct. The overall goal of the 1998 Sedimentation Study was to provide baseline information for making informed decisions related to mitigation of this sediment loading. Specific objectives of the investigation were to: (1) evaluate the rate of soil erosion within the PSCW, and identify influencing factors such as land use and natural processes; (2) identify and rank high erosion source areas; (3) assess the magnitude of sediment delivery into the lower fan area; and (4) develop and evaluate the effectiveness of best management practices (BMPs) for management of sediment production and reduction of sediment loads. A combination of literature review, model analyses, and field inventory and measurement techniques were applied to the study to address the specific objectives. Major findings are summarized in the following discussion.

The main source of sediment transported to the lower Panoche Creek fan was mainstem streambank and streambed erosion near the confluence of Panoche Creek and Silver Creek. Minor sources of sediment transport include natural hillslope erosion in the northern Tumey Hills, the hills near Idria, Griswold Canyon, and the hills west and north of the confluence area. Natural hillslope erosion has been accelerated by livestock-related denudation of vegetation in upland and riparian areas of the Silver Creek drainage. However, the effect of livestock on sediment loading to Panoche and Silver Creeks appears to be small in most areas, relative to the magnitude of streambank and streambed erosion. The Panoche Creek channel, downstream from the confluence area, has experienced dynamic geomorphic change over the past 60 years. For the 1998 Sedimentation Study, historical changes since 1924 were characterized, and geomorphic effects of 1998 floods were described. Annual sediment yield estimates for the PSCW, ranging from 500 to 13,500 tons/square mile per year, were computed and compiled. Streambank and streambed erosion occurs in other portions of the PSCW, but not to the extent observed in the confluence area.

Based on observations of effects from the 1998 flooding, the following trends were noted: (1) bank erosion was prevalent in the reach of Panoche Creek near the confluence area; (2) deposition was prevalent in the reach of Panoche Creek downstream of I-5; (3) bank erosion in reaches downstream of the confluence was localized, occurring mainly on the outside of bends; (4) there were short reaches of the channel (several hundred feet long) where the channel migrated tens of feet laterally into the adjacent terrace or alluvial fan deposits in 1998; (5) abundant sediment was deposited upstream of two flow constrictions, the bridge crossing lower Silver Creek (just upstream of the confluence of Panoche and Silver Creeks) and the Fairfax Road bridge (next to the California Aqueduct siphon crossing); and (6) little hillslope-derived sediment directly entered the channel from slopes downstream of the confluence area.

Impacts associated with livestock utilization in the lower elevations of the PSCW were noted for the 1997-1998 grazing season. These impacts were concentrated around drainages in both upland and riparian areas of Silver Creek. Herbaceous plant cover was low to absent in some of the drainage bottoms, and impacts to shrub populations were also noted. Much of the riparian vegetation along Silver Creek was heavily impacted by livestock congregation, and these impacts contribute to bank erosion and disturbance of the native plant community. Outside the heavily impacted areas, vegetation cover was excellent in 1998, allowing many upland drainage courses to act as buffers for potential sediment delivery downstream. Livestock utilization in the western and southwestern areas of the watershed was light to moderate, and was not a significant influencing factor for sediment transport from these areas.

As part of the 1998 Sedimentation Study, BMPs were evaluated individually and in selected combinations (scenarios) in terms of their effectiveness, implementability, and relative cost for reducing sediment loading in the PSCW upstream of I-5. From the evaluation of BMPs, it was observed that revegetation in selected appropriate areas, in conjunction with modifications of grazing practices in the highly erodible upland and sparsely vegetated riparian areas in the Silver Creek drainage, would restrict erosion from upland source areas and provide a riparian buffer to reduce the transport of sediment into streams. However, implementation of this scenario would result in a relatively small change in total sediment yield from the PSCW compared to the large amount of streambank and streambed erosion that occurs during major runoff events. Construction of runoff detention facilities in the upper PSCW was also evaluated to address the potential for streambank and streambed erosion. The preliminary analysis showed that construction of small runoff detention facilities, also known as "erosion control structures", may result in a significant reduction in peak flood flow rates and decreased flood stages. Streambank erosion and in-channel production of sediment should be reduced as a result of a decreased height of floodwater and potentially decreased flood flow velocities. Therefore, erosion control structures in the upper watershed, in conjunction with re-establishment of a vegetative riparian buffer area in the Silver Creek drainage, may provide a major benefit in terms of reducing total sediment yield from the PSCW.

A detailed feasibility investigation was recommended for the erosion control structure BMP scenario. The 1998 Sedimentation Study recommended that this evaluation include a quantification of the effect of these facilities on reduction of downstream streambank and streambed erosion. In addition, to address management of sediment in areas downstream of I-5, a focused, detailed investigation into the feasibility of a floodplain corridor, or other BMPs, was highly recommended.

3.0 THE FLOODPLAIN CORRIDOR STUDY

This Floodplain Corridor Study included evaluation of several alternatives for the Panoche Creek floodplain that would meet flood protection goals as well as possible management scenarios to meet specific water quality goals (North State Resources et al., 1999). The objective of the Floodplain Corridor Study was to identify and evaluate corridor alternatives for the Panoche Creek floodplain that would meet the following goals established by the BOR: (1) improve water quality with respect to selenium; (2) provide flood protection for Mendota and Firebaugh; (3) retire low productivity, drainage-impacted agricultural lands; and (4) create a wildlife and recreational corridor. The Central Valley Improvement Act Land Retirement Program provided funding for the study.

3.1 Utilization of Previous Studies

Field surveys were conducted to gather new information for the feasibility study. However, most of the background information was derived from previous studies, which were reviewed by North State Resources et al. (1999). A complete list of reviewed references is provided in the Floodplain Corridor Study. Many of these studies are summarized in later sections of this Technical Memorandum. A subset of available data was used by North State Resources et al. (1999), depending on the data quality required for their analyses. Hydrologic, hydraulic, and water quality from the following sources were utilized in the Floodplain Corridor Study: the U.S. Army Corps of Engineers (COE) (1994); California Department of Water Resources (DWR) (1987); COE (1995); and USGS (2001a).

The Floodplain Corridor Study calculated total sediment loads corresponding to the 10-, 25-, 50-, and 100-year storm events using the COE (1994) design flood hydrographs. The following assumptions were used in the sediment loading calculations: (1) bed load comprises 10 percent of the total suspended load; and (2) 58 percent of the suspended load is silts and clays. These assumptions were based on a 1992 DWR study performed in the nearby Arroyo Pasajero watershed and 1998 data collection. Estimates of annual sediment loading were calculated by applying the sediment discharge relationships to recorded daily mean flow measurements at the USGS "Panoche at I-5 gage" for the period of record. The study calculated a unit load of 653 tons per square mile per year for annual sediment load versus estimates by SCS (545), USBR (1,090), and MFG (800-1,600).

A detailed discussion of selenium toxicity, biogeochemistry, and transport in the study area was provided in the Floodplain Corridor Study. The study stated that selenium is mobilized from dry soils by rising groundwater or streambank erosion when the water is oxygenated or polluted with nitrate. According to the study, these conditions are common in the upper Panoche and Silver Creek drainages due to grazing activities and reductions in the amount of much of the large plant cover in the basins. Selenium in solid form is harmless unless ingested directly, but soluble forms of selenium in the soil are easily converted to oxidizing conditions, such as occurs from flooding. Soluble selenium does not coexist for long with biota; it is mainly found near seeps and tile drains where vegetation is absent and selenium loading is high. In most cases in nature, selenium uptake that causes toxicity problems is expected via the food chain. Discussion of food web toxicity and upland versus wetlands selenium issues is also provided in the Floodplain Corridor Study.

3.2 Methods of Analysis

The analysis in the Floodplain Corridor Study involved: (1) establishing design criteria and (2) identifying regulatory requirements and constraints. Design criteria were developed from previous studies, as cited above. These previous studies provided hydrologic, hydraulic, sediment loading, and biologic/selenium loading data. The following regulatory requirements and constraints also were identified: (1) NEPA, Clean Water Act, Endangered Species Act, and other regulatory tools; and (2) other environmental constraints and concerns. These other constraints and concerns included: (1) consideration of sedimentation impacts and elevated selenium concentrations in receiving waters; (2) design for dry area vs. seasonal wetland so that selenium accumulation during ponding does not occur; and (3) promotion of terrestrial vegetation vs. vegetation that will take up selenium.

The following alternatives were developed and analyzed to address flood protection and water quality goals as part of the Floodplain Corridor Study: (1) Total Capture; (2) Capture and Release; and (3) Facilitated Transport. Total Capture involves containing floodwater and sediment in a single, expansive detention basin located immediately downstream of I-5, where the waters ultimately percolate to the underlying aquifer. Capture and Release involves temporarily detaining the floodwater and sediment in a single, expansive detention basin located either adjacent to the Mendota Wildlife Management Area, or about 5 miles to the northwest. Facilitated Transport involves conveying the floodwater and sediment directly to the Fresno Slough via a corridor that would extend from I-5 to the Slough. These three alternatives were evaluated for floodwater volumes, sediment loads, and selenium loads for the 100-, 50-, 25-, and 10-yr flood events.

The following major assumptions were applied to the analysis: (1) dissolved selenium concentration of 50 ug/L in floodwater; (2) bedload is 10 percent of the total suspended load, containing no sediment-adsorbed selenium; (3) 58 percent of suspended sediment load is composed of silt and clay, considered unsettleable load; (4) 42 percent of suspended sediment is considered settleable; (5) 58 percent of sediment-adsorbed selenium load is composed of silt and clay, considered unsettleable load; and (6) 42 percent of sediment-adsorbed selenium load is considered settleable.

3.3 Results

The Floodplain Corridor Study results regarding selenium in the stream system are summarized below followed by a summary of results for the alternatives evaluated:

- Panoche Creek frequently floods at its terminus at Belmont Avenue. Panoche Creek floodwaters: (1) carry large amounts of dissolved selenium and selenium-laden sediment; and (2) cause extensive damage to crops, irrigation canals, roads and structures in Mendota and Firebaugh.

- Panoche Creek flooding degrades water quality and poses a selenium toxicity threat to wildlife. Water quality is degraded by: (1) leaching of applied irrigation waters and evaporation on the selenium-laden flood deposits which contribute to elevated selenium levels (up to 200 µg/L) in the shallow ground water; and (2) selenium-laden floodwaters that are conveyed to the San Joaquin River and Mendota Pool/Fresno Slough. The study noted that probably due to indirect storm flows from Panoche Creek, both the Mendota Pool and San Joaquin River below Mendota dam had not met the 2 µg/L selenium criterion (about 57 percent of the time) or less than 5 µg/L (about 20 percent of the time) over the four years prior to the study.

Evaluation of Alternatives

Results of the Floodplain Corridor Study feasibility analyses of the multi-objective alternatives are comparatively summarized in the report according to: (1) acres of land retired; (2) reduction of irrigation demand; (3) upland and riparian habitat created; (4) level of operator attention required; (5) water quality improvements; and (6) estimated first year operation and maintenance costs assuming each alternative is designed to handle the 100-year flood event. Highlights of the findings are summarized below:

(1) Total Capture is most beneficial in terms of retiring agricultural land, reducing irrigation demand, creating upland and riparian habitat, and improving water quality, including selenium conditions, in the San Joaquin River, Fresno Slough and Mendota Wildlife Management Area (MWMA). However, it also has the highest cost ($1.9 Million) and requires a moderate level of operation and maintenance.

(2) Capture and Release is the second most beneficial alternative in terms of retiring agricultural land, reducing irrigation demand, and creating upland habitat. It also provides the benefit of creating habitat adjacent to the MWMA. However, it provides the least amount of riparian habitat, requires a high level of operator attention, and has the second highest cost of the three alternatives analyzed ($1.2 Million). This alternative improves water quality in the Fresno Slough but, in contrast to Total Capture, does not improve selenium conditions in the San Joaquin River and the MWMA. The study notes that Capture and Release would probably degrade the San Joaquin River compared to existing conditions.

(3) Facilitated Transport provides the least amount of benefit in terms of most of the objectives listed in Table 1 and does not improve water quality or selenium conditions in the San Joaquin River, Fresno Slough, or MWMA. However, Facilitated Transport does: (1) create as much and more riparian habitat than Total Capture and Capture and Release, respectively; (2) require the least amount of operator attention; and (3) have the lowest estimated cost of implementation ($0.7 Million).

Total Capture was determined to be the only option of the three analyzed that would substantially improve current selenium conditions and meet water quality objectives in both the MWMA and San Joaquin River.

<u>Uncertainty/Error in the Evaluation of Alternatives</u>

The feasibility analyses of the multi-objective Panoche Creek project alternatives were performed based on the best available information that was limited to: (1) selenium and suspended sediment data collected during the wetter than normal 1997-1998 rainy season; (2) flow data over a limited period of record from the USGS "Panoche Creek at I-5" gaging station; and (3) previous hydraulic and hydrology analyses. In addition, several assumptions were made regarding sediment and selenium loading. The study emphasized that to conclusively evaluate and compare the alternatives the following would be required:

(1) Additional sediment data collection on Panoche Creek over an entire season to characterize the nature and composition of the sediment load for design;
(2) A model of sediment transport/hydraulics in the Panoche Creek corridor system;
(3) Basin percolation testing to estimate percolation losses and hindrances to percolation;
(4) More flow and storage data for upstream reservoirs to know what is available should additional dilution flows be necessary;
(5) Selenium data for the Fresno Slough and San Joaquin River above the Mendota Pool; and
(6) Modeling of the transport of selenium mass percolated to groundwater or discharged to surface water and its impacts on local groundwater supplies.

4.0 THE SUMMERS REPORT

The Summers Engineering (1998) study, typically referenced as the “Summers Report”, was prepared for City of Mendota, the Panoche/Silver Creek Coordinated Resource Management Planning Group (CRMP) and the Silver Creek Drainage District. The purpose of the Summers Report was to summarize the historic Panoche/Silver Creek flooding problems, review long-term watershed management options proposed by the CRMP, recommend a flood proposal to minimize the flooding impacts, and develop a preliminary cost estimate for the flood control proposal. The Summers Report has been used as an erosion and flood control proposal for Mendota and surrounding agricultural areas.

The report provides useful economic impact estimates of flooding from the 1998 flood event and other general maintenance costs relative to smaller flooding events. Economic impacts are estimated for the City of Mendota, the agricultural stakeholders, and the three irrigation districts located within the watershed. Photo documentation of the 1998 flood and sedimentation from 1995 flooding is also included

A brief history of agricultural development was provided in the Summers Report, and a map was appended that displays the layout of the Broadview Water District (WD), Firebaugh Canal WD, and Westlands WD and the extents of the Silver Creek Drainage District relative to the PSCW boundary. A brief history of the water districts documents that land in the Firebaugh Canal WD has been irrigated for agricultural production since the early 1900s and the lands in the Broadview WD and the Westlands WD have come under intensive irrigation following the completion of the Delta Mendota Canal in the 1950s and the Central Valley Project, San Luis Unit, in the 1960s.

4.1 Hydrology

The hydrology discussion notes that a review of the 1922-1923 flow records indicated that approximately 60 percent of the total runoff came from Silver Creek that drains only approximately one-third of the upper watershed area (upstream of I-5). The report offers that this may result from greater percolation losses in Panoche Creek as it flows through the Panoche Valley and that the Silver Creek drainage is located in a more mountainous area and has less percolation losses. Another explanation suggests that the storms that year may have produced more precipitation in the Silver Creek drainage.

The report lists peak flows and 1-day, 3-day, and 10-day flood volumes for the 10-, 25-, 50-, and 100-year flood events from 1981 USBR and COE analyses. The report lists 14 peak flow rates (some with dates), annual precipitation values, and some annual flow volumes for a discontinuous period of record from 1950-1998. The peak flow rates are from five different sources. There is a key discrepancy for the 1998 peak flow rate; the value listed for 1998 (6,500 cfs) from the Firebaugh Canal WD records is footnoted, whereas the footnote indicates that the USGS reported 17,000 cfs for that year. These results indicate that the flood was either approximately a 20-year event or a 100-year event based on the flood frequency determination listed. The report also states that although flooding has occurred for many years, recent flood events appear to have caused substantially greater damages.

4.2 Historic Flooding Impacts

The Summers report provides a description of flooding impacts and economic estimates for the City of Mendota, agriculture stakeholders, water districts, and road maintenance agencies. A brief summary for each of these entities follows.

City of Mendota

During high peak flow events, a portion of the flood waters travel down Belmont Avenue and inundate roughly two-thirds of the city. Primary impacts include the city's sewer system and roads such as State Highways 33 and 180, which have been restricted to single lane traffic or road closure when flooding occurs.

Agricultural

Agricultural damages account for the highest percentage of all flood damages. Damages include total crop losses, lost land preparation costs, silt removal and cleanup costs, land releveling costs, on farm irrigation system damages, delays in crop planting, and reduced crop yields in flood years and subsequent years due to sedimentation impacts. The Summers report also states that USGS studies report that sediment deposition in recent flood events tested at 400 parts per billion (ppb) for selenium and that continuous deposition of sediment high in salts and selenium will cause decreased agricultural productivity and degradation to groundwater quality.

Water Districts

Westlands WD water supply pipelines and some drainage facilities used for on-farm recirculation have suffered damages from siltation. Damages to the Firebaugh Canal WD canal levees, district pumps, electrical panels and telemetry systems occur to a greater or lesser extent depending on the magnitude of the flood flows. The third lift canal is initially overtopped and, subsequently, the second and first lift canals are affected depending on the flood magnitude. Floodwaters that reach the canals eventually drain to the Mendota Pool and degrade water quality of that waterbody. The Broadview WD pumps and motors also are damaged during significant peak flow events.

Road Maintenance

The I-5 bridge was subject to some erosion and bank sloughing during the 1998 event and there are some siltation issues at the inverted siphon crossing of the California Aqueduct. Also, during 1998 flooding, erosion occurred at the footings of the Panoche Creek/Fairfax Avenue bridge crossing of the California Aqueduct. Storm drains along State Highways 33 and 180 and ongoing flooding reduces the life of these highways. Large floods also have the potential to damage the Southern Pacific railroad tracks that run northwesterly along the lower end of the watershed.

4.3 Proposed Project Approaches

The Summers report presents the following four proposed project options to minimize flooding and improve water quality: (1) erosion control structures; (2) stream channel restoration; (3) a flood control dam; and (4) a floodway. Cost estimates are also provided for three of these options. The four proposed approaches are summarized below.

Erosion Control Structures

The proposed approach for the erosion control structures would be to construct small dams on individual creeks in the upper watershed. The dams would provide temporary storage of stormflows in the upper watershed, thus reducing peak flows downstream. The Summers report estimates that it is conceivable that the peak flow for the 50-year storm could be reduced 50 percent by constructing several small dams. The report provides a cost estimate of $12.8 Million to construct eight erosion control structures upstream of I-5 to detain these peak flows.

Stream Channel Restoration

The proposed approach recommends the improvement of vegetative growth adjacent to various creeks should improve the riparian habitat, reduce flows, minimize erosion, and result in improved water quality. Most of the degraded habitats were found in the Silver Creek tributaries that have poor soils and along Silver Creek. In addition, Panoche Creek just upstream of I-5 has been impacted by some in-stream gravel mining operations as well as off-road vehicle use. Proposed improvements consist of improving livestock and rangeland management practices and revegetation along riparian areas. No cost estimate was provided in the report.

Flood Control Dam

The Summers report proposed a flood control dam downstream of the Panoche/Silver Creek confluence to manage and control high runoff. The report refers to studies done by the USBR that suggest a dam could be efficiently built with proper geologic evaluation. The Summers report indicates that a flood control dam could handle a 50-year event, store 18,000 acre-feet of water and 8,000 acre-feet of sediment. The report provides a cost estimate of $30 Million to construct the dam.

Floodway

The fourth approach discussed was a floodway, in combination with small erosion control structures and/or a smaller flood control dam. A floodway could pass reduced flood flows or uncontrolled releases to the Fresno Slough. For the floodway proposal with erosion control structures or a large flood control structure, the floodway capacity would have to be 6,000 cfs or 500 cfs, respectively. The Summers report provides a cost estimate of $23 Million to construct a 700-ft wide floodway, with 6,000 cfs capacity designed to handle the 50-year flood event.

4.4 Three Project Proposals

The report subsequently lays out three similar project options entitled: (1) erosion control structures proposal; (2) Mendota proposal; and (3) riparian habitat and flood control corridor proposal. These have been proposed by the CRMP, City of Mendota, and federal agencies, respectively. The Summers report notes that the proposals have the common goal of minimizing flood impacts from Panoche Creek and a combination of the proposals may be the optimal solution for the flooding problems. Highlights of the proposals are summarized below.

<u>Erosion Control Structures Proposal</u>

The Summers Report proposed the construction of erosion control structures in the upper watershed with the 700-ft wide, 6,000 cfs capacity floodway in the lower watershed built to protect against the 50-year flood event as one project alternative. The proposed floodway would require 5-ft high embankments built with a slope that is less than the natural slope to reduce scour velocities. Other details include small gabion structures to provide grade control, a diversion structure, road crossings for State Highways 33 and 180 and county roads, and a sedimentation basin.

<u>Mendota Proposal</u>

In March 1998, the City of Mendota endorsed an $8 million proposed project that would reduce annual flooding impacts by 75 percent. The proposed project would entail construction of a 6-mile drainage channel on the south side of Belmont Avenue down to Ohio Avenue. Just east of Ohio Avenue, a 3-mile green belt is proposed to carry flows south and east to a 40-acre settling basin on the east side of Highway 180 to allow settling before flows are discharged into Fresno Slough.

Riparian Habitat and Flood Control Corridor Proposal

Under the auspices of the Central Valley Project Improvement Act-Land Retirement Program, the BLM and BOR were in the initial phase of developing a riparian corridor along the Panoche Creek channel downstream of I-5. However, this proposal has not been implemented. The proposal involved acquiring land along Panoche Creek to provide: (1) flood control; (2) riparian and upland habitats; and (3) water quality improvements. Initial considerations were to create a meandering 19-mile long by 1-mile wide corridor from I-5 to the Mendota area.

The following proposed benefits of the flood corridor project were identified in the Summers Report: (1) long-term reduction of flooding impacts to the agricultural lands and the City of Mendota on the Panoche Creek alluvial fan; (2) watershed habitat enhancement; and (3) reduction in the deposition of sediment and floodwater that may by a source of selenium on the alluvial fan. The proposed cost estimate for implementing the Riparian Habitat and Flood Control Corridor was $23 Million and the estimated cost for annual operations and maintenance was $62,000. The Summers report also provided a budget estimate for conducting a more detailed feasibility study and CEQA and NEPA documentation required for implementation of the three proposed projects. The budget estimate was $700,000 and $220,000 for the feasibility study and CEQA and NEPA documentation, respectively.

5.0 BENEFITS ANALYSIS

The Economic and Conservation Benefits Analysis (MFG, 2001) typically referenced as the "Benefits Analysis" was prepared for the Westside Resource Conservation District (WRCD) using funding granted to the WRCD by the Packard Foundation. The overall goal of the PSCW Benefits Analysis was to provide the information necessary to understand and assess the potential economic and conservation/ecosystem benefits of implementing sediment control best management practices (BMPs) in the Panoche Silver Creek Watershed (PSCW). Multiple benefits related to implementation of sediment control BMPs were considered, including ecosystem health, water quality, flood control, economic impact, and agricultural productivity. The Benefits Analysis was not a comprehensive benefit-cost analysis, but provides cost estimates for BMP implementation that were developed and compared with predicted benefits.

The Benefits Analysis estimated the ecological and economic value for the following four BMP scenarios:

(1) Erosion control structures in high runoff source areas;

(2) Large flood-control dam near the Panoche-Silver Creek confluence;

(3) Significant streambank protection; and

(4) Grazing management changes to improve vegetative cover in riparian and upland areas.

The BMP scenarios were evaluated in terms of ecological and economic benefits of sediment reduction, erosion control, improved water quality, and reduced flood hazard (reduced peak flows). Quantitative and qualitative benefits were estimated for upper watershed and lower watershed landowners, stakeholders, and ecosystems. The results of the analysis performed for each scenario and the conclusions and recommendations of the Benefits Analysis are summarized below.

5.1 Erosion Control Structures

The first BMP scenario involved the construction of seven erosion control (catchment) structures that would temporarily detain flows from storm events, allowing a reduction in the peak flows downstream. The analysis noted that a proportionately larger volume of runoff originates in the upper reaches of PSCW because of the higher precipitation relative to the lower watershed. Each of the catchments was assumed to impound water to a maximum depth of 20 feet with a maximum impounded surface area of 40 acres. The benefits of implementing seven erosion control structures in the upper watershed included:

(1) Overall reduction of peak flow and streambank erosion downstream from runoff detention facilities (in the upper and lower watershed areas);

(2) Reduction of area of inundation and area of sediment deposition on the alluvial fan (in the lower watershed);

(3) Potential reduction or avoidance of property damage due to overbank flooding on the alluvial fan;

(4) Net benefit when considering the implementation cost relative to the reduction in potential damage to the lower watershed for larger flow events; and

(5) Improved ecosystem health, water quality, flood control, and economic/agricultural productivity.

The analysis reported that the extent of benefits gained from implementation of the erosion control structures is dependent on the magnitude of flood event and corresponding reduction of the incoming peak flow. While some local benefits in terms of streambank erosion reduction would occur immediately downstream from these structures, the greatest benefit would be realized in the lower watershed where flooding causes the largest amount of damage.

5.2 Large Flood Control Dam

The second BMP scenario involved construction of a large dam on Panoche Creek upstream from the Panoche-Silver Creek confluence. The structure would be designed to detain more than 60 percent of the total runoff volume that normally reaches I-5. Construction of a large dam near the Panoche-Silver Creek confluence was expected to provide the same range of benefits as would implementation of the erosion control structures, with the exception of the large costs required. The analysis concluded that the capacity of a large dam to detain large flows would be substantially greater, but the benefits of a large dam did not outweigh the costs.

5.3 Streambank Protection

The third BMP scenario involved implementation of various streambank protection measures in the upper watershed. A combination of "soft" streambank BMPs and pipe-and-wire revetment was assumed for the scenario. In all areas, pipe-and-wire revetment would be installed to accelerate revegetation of the streambank areas and provide lower erosion rates while vegetation develops. Fencing would also be desired to exclude cattle grazing from areas recovering with new plantings and young vegetation.

The potential benefit from implementing this scenario would be limited to the adjacent landowner and, therefore, was considered most suitable for locations where property or facilities could be lost due to streambank erosion.

The analysis concluded that, from a flood reduction perspective, little or no benefit would be realized to lower watershed interests from streambank actions in the upper watershed. In terms of sediment load, some reduction could result from implementing long reaches of streambank BMPs, especially near the Panoche-Silver Creek confluence where extensive streambank erosion occurs. However, the overall effectiveness of these BMPs for reducing streambank erosion in long stream reaches and for the overall stream system would be limited by the ongoing natural processes (MFG, 1998).

5.4 Grazing Management Changes

Grazing management changes, the fourth BMP scenario, would involve improvement of vegetative cover in riparian and upland areas through implementation of measures that mainly reduce the impact of cattle grazing near streams. The following four management components comprised the fourth scenario: (1) limited season of use; (2) designated target residual dry matter levels; (3) riparian pasture creation; and (4) water systems development. Each of these components would provide improvement in the riparian areas and, to a lesser extent, in the upland areas.

The primary benefits of the fourth BMP scenario was improvement in vegetative cover for grazing, which also increases cattle carrying capacity. The analysis concluded that changing grazing management practices in the upper watershed would probably have a minimal or non-quantifiable effect on reducing flood damage in the lower watershed. However, the analysis suggested that implementing the BMP at strategic locations in the upper watershed could result in water quality benefits to the lower watershed.

The analysis listed the following benefits that could result from improving vegetative cover in both riparian and upland areas:

(1) Dissipation of stream energy associated with high peak flows;

(2) Filtering sediment and capturing bedload;

(3) Improvement of downstream water quality;

(4) Improvement of water retention as well as groundwater recharge;

(5) Development of root masses that are capable of stabilizing streambanks against erosional forces; and

(6) Improvement of wildlife habitat and game hunting resources.

5.5 Recommendations

The Benefits Analysis recommended that other potential benefits of sediment control BMPs be evaluated further, if warranted, including: (1) socio-economic impacts in terms of total farm revenue, farm profit, regional output, regional income, and regional employment; and (2) potential benefits to recreational values and hunting resources.

The Benefits Analysis recommended that future planning for BMP implementation should focus on: (1) erosion control structures, and (2) grazing management changes. The analysis recommended the following:

(1) A large dam BMP scenario should not be pursued unless construction costs can be reduced significantly;
(2) The streambank BMP scenario might be worth pursuing on a limited basis to demonstrate the potential for reducing damage to high-value property in selected locations but widespread implementation is not advised;
(3) The erosion control structures would provide a large benefit in flood damage reduction in the lower watershed at low cost and low risk relative to the large dam BMP scenario; and
(4) Profitability could be increased, land stewardship improved, and riparian function restored by the implementation of recommended grazing management changes.

6.0 ADDITIONAL RELEVANT STUDIES

The following types of studies were identified and reviewed to further define selenium and sediment sources in the watershed: (1) USGS discharge, sediment, and selenium data collection efforts; (2) selenium source characterization studies; (3) miscellaneous geologic investigations; (4) hydrologic studies; and (5) hydraulic studies. Brief summaries of the additional studies reviewed are provided below.

6.1 USGS Stream Gage, Sediment, and Selenium Monitoring at I-5

A review of the USGS records for gaging stations within the PSCW was performed to identify water quality data available for the watershed (USGS, 2001). Table 1 provides a summary of the streamflow and water quality data collected at the USGS gages within the PSCW. For the "Panoche Creek Below Silver Creek near Panoche, California (USGS #11255500)" gaging station, a total of 6 water quality samples with corresponding discharge measurements were collected during four sampling events from November 17, 1965 through January 24, 1967. Also, for the "Panoche Creek at I-5 near Silver Creek, California (USGS #11255575)" gaging station, a total of 69 water quality samples with corresponding discharge data were collected during 20 sampling events between January 19, 1998 and April 8, 1999. Of the 20 sampling events, 19 occurred during the water year 1997-1998. Provisional daily discharge data for the USGS #11255575 gaging station are available for the 2000-2001 water year, however, no water quality data are available. Provisional data may be subject to significant revisions when the USGS reviews and adjusts the data at the end of the water year according to Techniques of Water-Resource Investigations of the U.S. Geological Survey (TWRIs) (USGS, 2001b). A more detailed discussion of streamflow records and hydrology is presented in Section 6.3.

Table 2 provides a listing of the PSCW sediment and selenium data available for the period of record. The 6 water quality samples collected at USGS #11255500 were analyzed for suspended sediment concentration and particle size distribution but not for selenium. Of the 69 water quality samples collected at USGS #11255575, a total of 9 were analyzed for: (1) suspended sediment concentration; (2) total and dissolved selenium; and (3) detailed suspended sediment size distribution. A total of 37 were analyzed for the parameters listed above, but the size distribution of the suspended sediment was limited to reporting just the percent finer than 0.062 mm (fines). A total of 46 were analyzed for only suspended sediment

concentration and percent finer the 0.62 mm but not for total or dissolved selenium. The remainder of the watery quality samples collected at USGS #11255575 were analyzed for parameters other than suspended sediment or selenium.

The majority of the selenium data available for the PSCW was collected during 1998 storm events. The USGS collected a total of 32 samples in Panoche Creek at the USGS gage at I-5 from February 2 through February 24, 1998. Samples included measurements of instantaneous streamflow, sediment concentrations, selenium, and electrical conductivity. No bed load measurements were made. The USGS sediment and selenium measurements are summarized on page 35 of the Floodplain Corridor Study (North State Resources et. al., 1999). While the data were considered preliminary and were not published at the time of the Floodplain Corridor Study, they were considered the best available data set to evaluate sediment and selenium loading in Panoche Creek. The majority of the preliminary data used in the Floodplain Corridor Study were identical to the final data listed in Table 2. The USGS made a couple of minor corrections and rounded off to appropriate significant digits for the suspended sediment concentration data.

The USGS had plans to collect 2-4 sets of storm samples during the 2001-2002 rainy season, including bedload samples, at the Panoche Creek at I-5 gaging station (Freeman, 2001), however, significant flow events did not occur. The samples would have been analyzed for particle size distribution and water chemistry including total and dissolved selenium.

6.2 Selenium Source Characterization

Selenium sources were characterized in the PSCW during three different studies: (1) *Geologic Sources, Mobilization and Transport of Selenium from the California Coast Ranges to the western San Joaquin Valley: A Reconnaissance Study* (Presser et. al, 1990), referenced as the "Presser Study"; (2) *Preliminary Assessment of Sources, Distribution, and Mobility of Selenium in the San Joaquin Valley, California* (Gilliom et al., 1989), referenced as the "Gilliom Study"; and (3) the NRCS Western Fresno County Soil Survey (Arroues, 2002), referenced as the "Arroues Survey".

The Presser Study provides valuable information to better understand selenium source and transport issues in the PSCW. The main conclusions of this report are that selenium can be transported in both soluble and insoluble forms, and the transport of selenium is episodic and caused by infrequent flood events. Other important study results and conclusions relating to the sources and transport of selenium include:

- The primary source rocks of selenium to the west-central San Joaquin valley are from the Upper Cretaceous-Paleocene Moreno and Eocene-Oligocene Kreyenhagen Formations.
- Alternative sources of selenium investigated in the Presser study, including Cretaceous and Tertiary sandstones, Pliocene-Pleistocene continental rocks, acid mine drainage from New Idria Mercury Mining District, and waters from the eugeosynclinal Franciscan assemblage and serpentines, are completely barren of selenium.
- Elevated concentrations of selenium, indicating a hydrologic reservoir of selenium to be transported, were found in four water sources: (1) ephemeral streams, (2) runoff waters from flushing winter storm events, (3) throughflow in the unsaturated zone, and (4) groundwater in wells and seeps associated with structural synclines.
- A temporary geologic sink of selenium forms when selenate (SeO_4^{2-}) replaces sulfate (SO_4^{2-}) in sodium and magnesium sulfate minerals.
- The geochemical cycle for selenium is similar to that of sulfur. The basic steps in selenium cycling in the PSCW are weathering of elemental selenium (Se^0) and metallic selenides (example, $FeSe_2$) in parent rocks or sediments → weathering under acidic and oxidizing conditions forms selenite (SeO_3^{2-}), weathering under alkaline conditions forms selenate (SeO_4^{2-}) → Selenite forms stable ferric oxide-selenite ($Fe_2(OH)_4SeO_3$) complexes and resulting in immobilization of selenium, selenate forms compounds that are soluble and mobile.
- Two primary transport mechanisms were identified: (1) rainfall-runoff transport of soluble salts from erosional and depositional shale land forms oxidized to selenate to the valley floor; and (2) landslides, slumps, and mudflows causing mechanical distribution of fine-grained materials which are carried as suspended load in a residual insoluble fraction to the head of the Panoche Creek alluvial fan during hydrologic events.
- Extractions of selected samples of residual deposits of suspended load material at the head of the fan show that 95 percent of the selenium is in a form resistant to solubilization.

- Cycling of wetting and drying events and evaporation in an arid climate leads to an accumulation of selenium instead of constant low mobilization and transport, thus developing elevated levels of selenium in the fans and interfan areas.
- Concentrations of dissolved selenium range from 44 to 57 µg/L for discharges ranging from 25 to 85 cfs.

The Gilliom Study presents preliminary findings about sources, mobilization, and transport of selenium in the PSCW and surrounding region. The paper also provides a list of general implications for water management based on the preliminary findings. The general implications are meant to facilitate researchers in establishing priorities to complete studies and guide future work. Some of the findings that relate to selenium sources and transport properties are summarized below:

- A clear link exists between elevated soil selenium concentrations and soils formed on weathered Coast Range sediments of the Kreyhagen Shale and Moreno Formations.
- Concentrations of selenium are highest in soils found in interfan areas east of Monocline Ridge. These concentrations exceed 0.36 mg/kg, the 90th percentile of concentrations for all southern San Joaquin Valley soils.
- An exact spatial correlation of high-selenium soils and high-selenium groundwater was not found.
- Groundwater flow is controlled by the Corcoran Clay Member of the Tulare Formation which divides the system into an upper semiconfined zone and a lower confined zone. Highest concentrations of selenium in groundwater are found in the upper part of the semiconfined zone in Coast Range sediments.
- High-selenium soils are a readily available source of selenium to shallow groundwater where irrigation occurs. Water percolating through fields irrigated for 45 years but drained for less than 8 years contains selenium concentrations greater than 100 µg/L.

The Arroues Survey was conducted as part of an effort to update soil survey information in the region. Kerry Arroues, of NRCS in Hanford, initiated the soil survey for Western Fresno County in the 1980s and is finalizing the survey for release to the public in 2002 (Arroues, 2002). Therefore, no summary is provided in this document. However, results of the soil survey will be included in subsequent CALFED project documents including the PSCW Management and Action Plan. The scope of the new soil survey is limited to areas in Fresno County and, therefore, will not include portions of the watershed located in San Benito County.

6.3 Miscellaneous Geologic Investigations

Numerous geologic investigations in the PSCW region have traditionally focused on mineralogic and oil resource inventories, tectonic investigations related to the San Andreas Fault system, and understanding geomorphic processes and structural relationships of the California Coastal Range. Geologic mapping in the area was compiled by Dibblee (1971) and Bartow (1996) and distributed by the USGS. The stratigraphic nomenclature presented in the geologic maps represent interpretations of numerous geologic studies; consequently the naming and relationships of units and formations have changed over time. Geologic mapping by Bartow covers the majority of the Fresno County region in the upper PSCW while the Dibblee mapping covers a total of three 15-minute quadrangles that include the upper PSCW.

The PSCW region exposes folded and faulted upper Cretaceous and lower Tertiary strata that are confined within uplifted Franciscan terranes of the northern and southern Diablo Range. The Moreno Formation, Kreyenhagen Shale and Tumey Formation are part of the upper Cretaceous and lower Tertiary strata that have been identified as the primary geologic sources of selenium in the upper PSCW (Presser, 1990). The units are exposed in the headwater regions of Moody and Bitterwater Canyon and the region surrounding the confluence of Silver Creek and Panoche Creek. The Panoche Formation is a widely distributed unit in the upper PSCW that contains shale and claystone members similar in age, weathering, and depositional history to the Moreno Formation. The Panoche Formation was sampled in the Presser study and reported to contain slightly elevated concentrations of selenium.

6.4 Hydrologic Studies

Hydrologic studies for the PSCW have typically been hampered by a lack of historic streamflow data. Most gaging station installations have been operated for only short periods due to funding limitations and washouts during major runoff events. Hydrologic studies performed in the PSCW have typically used data collected at a USGS gaging station located on Panoche Creek below the confluence of Panoche and Silver Creeks. This station was installed in 1949 and discontinued in 1973 (USGS #11255500 Panoche Creek Below Silver Creek Near Panoche California). A new gaging station (USGS #11255575), installed on Panoche Creek at the I-5 bridge in the winter of 1997-1998, also provides daily and annual peak streamflow records. Table 1 provides a summary of available USGS streamflow records for Panoche/Silver Creek. The 1949-1973 streamflow record from the former station (upstream of I-5) is not continuous and data are not available for water years 1954 through 1957 and 1971. Therefore, only 19 years of annual peak flow records are available for this gaging station, and 3 of the 19 annual peak discharge flows were very small (less than 3 cubic feet per second (cfs) peak flows) because of the overall low flow during these years. In addition, daily flows were not recorded after the 1970 water year. Therefore, only 16 years of daily discharge data are available at the old USGS gage. For the new gaging station (USGS #11255575), daily data have been collected since December 1, 1997 and annual peak flows recorded for water years 1998-2000. The 2000-2001 and real-time provisional data for this gaging station can be obtained via the USGS website http://water.usgs.gov/nwis/discharge. Provisional data may be subject to significant revisions when the USGS reviews and adjusts the data at the end of the water year and publishes the data, typically in the following spring.

The following three hydrology studies are summarized below, and were also evaluated in the Floodplain Corridor Study: (1) Boyle Engineering, 1992a, *Development and Application of a Hydrologic Model, Panoche-Silver Creek Watershed Management Plan, Preliminary Draft Letter Report,* submitted to the BOR; (2) Department of Water Resources, San Joaquin District, State of California, December 1987,*Draft Report, Panoche-Silver Creek Flood Frequency Analysis*; and (3) COE Sacramento District. October 1994, *Cities of Firebaugh and Mendota, California, Reconnaissance Hydrology Study.*

The Boyle Engineering (1992a) study, a reconnaissance level hydrology analysis, was performed under contract to the BOR to determine peak discharges for the 10-, 25-, 50-, and 100-year events. Boyle performed watershed modeling using HEC-1, a standard COE hydrologic modeling program. In addition, an historic flood frequency analysis was performed using historic data from USGS # 11255500.

The DWR (1987) conducted a flood frequency analysis for Panoche/Silver Creek to address flooding problems. In addition to the aforementioned USGS gage data, the DWR study also used data collected at a gage installed by the DWR at the California Aqueduct near Fairfax Avenue between 1977 and 1980. In total, 24 years of annual peak discharges were used for the flood frequency analysis. The DWR estimated peak discharges and 3-day flood volumes for the 10-, 25-, 50-, 100-, and 500-year return periods.

The COE performed a hydrologic analysis in 1994 to determine the 10-, 50-, 100-, and 500-year flood hydrographs. The HEC-1 model used in the 1992 Boyle study was partially used in the analysis and re-calibrated using different procedures. The calibration was performed to fit the measured 1969 historical flood hydrograph which was the peak flow of record at that time (peak flows recorded in 1998 were larger than the 1969 flows). Results of the 1987 DWR study were also used in the COE analysis.

6.5 Hydraulic Studies

The following two hydraulic studies are summarized below, and were also evaluated in the Floodplain Corridor Study: (1) Boyle Engineering, 1992b, *Development and Application of Hydraulic Model, Panoche-Silver Creek Watershed Management Plan, Preliminary Draft Letter report*, submitted to the BOR; and (2) COE Sacramento District, June 1995, *Reconnaissance Report, Firebaugh and Mendota, San Joaquin River Basin, California Attachment B – Reconnaissance Study Panoche Creek, December 1994.*

The Boyle Engineering (1992b) study included modeling of 25.5 miles of Panoche Creek upstream of the California Aqueduct and 3.5 miles of Silver Creek upstream of the confluence with Panoche Creek. The modeling was performed to determine hydraulic parameters and velocities for various flows for various points of interest along the main channel for input to sediment yield and sediment transport models on the main stem. Boyle performed hydraulic modeling using HEC-2, a standard COE one-dimensional open channel water surface profile modeling program. Velocities for Panoche Creek at the California Aqueduct and I-5 crossing were estimated.

The objective of the COE (1995) reconnaissance level study was to delineate areas of inundation for 10-, 50-, 100-, and 500-year floods events and determine protection measures for the cities of Mendota and Firebaugh. COE staff indicated that the HEC-2 model was used to determine channel capacity and XRATE was used to determine gain/loss resulting from overbank flow (North States et. al, 1999). Floodplain information was based on USGS quadrangle sheets and data gathered during field investigations.

7.0 WATERSHED IMPROVEMENT PROJECTS

A small number of watershed improvement projects have been implemented in the PSCW over the past 30 to 40 years. The discussion in this section focuses on major types of projects implemented on private land (Section 7.1) and public land (Section 7.2). Approximate project locations are shown on Figure 2. This summary does not include studies or plans that have been conducted but not implemented.

7.1 Projects on Private Land

Numerous small erosion control dams and stock watering ponds were built in tributary drainages in the upper PSCW during the 1950s and 1960s. A few of these structures are still in use today as outlined below. The majority of these structures were poorly designed and improperly located. Over time, these structures fill with sediment and breach. Breached dam sites become large sources of in-stream sediment available for downstream transport.

In the early 1960s a small erosion control structure was installed on Charlie McCullough's property. The dam was designed to reduce downstream erosion by impounding storm runoff generated from a 369-acre watershed. The dam is a non-jurisdictional Class "A" structure designed in 1962 by James Tindall of the Soil Conservation Service (SCS). The dam was built to meet SCS specifications for a Class "A" erosion control dam including a 2:1 upstream face and 3:1 downstream face. A 16-inch drain culvert was installed through the dam fill material. A small spillway was constructed in Franciscan sandstone bedrock that is upstream of semi-consolidated Quaternary alluvium and still conveys flow during major runoff events. Flows in 1998 were the largest recorded since the dam was built. The 1998 flows removed accumulated sediment from the stream reach downstream of dam. The impact of cattle on the dam and spillway has been minimal and no maintenance has been performed since the dam was constructed. Little to no sediment has accumulated behind the upstream face of the dam.

A small stock dam was designed in 1960 to impound storm and spring-generated runoff. Based on the best available knowledge, the dam was built in the early 1960s and still exists today. The stock dam was designed to conserve water downstream of site and provide suitable water for cattle. The dam is located on William Butts property (as of 1960) in Moody Canyon at an elevation of approximately 2400 feet in the upper PSCW. Harry Prater of the SCS provided technical review and assisted with design and oversight of

the project. The dam specifications are 12 feet in height, 10 feet wide (at crest), and 75 feet long. A small flood spillway was designed for release of flood flow.

The Natural Resource Conservation Service (NRCS, formerly SCS), in cooperation with local landowners, initiated a variety of smaller watershed improvement projects in the upper PSCW. The general goal of these projects was to improve water
quality, and specific project objectives included:

1. Exclude livestock from watercourses,
2. Reduce bank erosion,
3. Reduce direct deposit of manure in water courses, and
4. Improve grazing distribution.

Personnel from the NRCS performed follow-up reconnaissance visits and indicated that projects were generally completed and functioning properly.

7.2 Projects on Public Land

The U.S. Bureau of Land Management (BLM) continues to initiate and manage water quality and rangeland health projects on public land within the PSCW (Figure 2). Goals of BLM rangeland management projects include:

- Reduce soil erosion and sediment delivery to stream channels,
- Improve riparian and rangeland vegetation and habitat,
- Environmental clean-up and site remediation,
- Improve compliance and enforce regulations by updating signs and patrols,
- Effectively manage livestock grazing, and
- Reduce human contact with mercury and mining waste.

Many of the BLM projects involve building livestock exclusion fencing to keep cattle out of riparian and other ecologically sensitive areas. Fencing riparian areas controls livestock access and helps accelerate recovery of heavily impacted areas. BLM has also adopted a green season grazing management policy that controls cattle access on public pasture land between the months of November through April.

7.3 Summary

Watershed improvement projects conducted on private and public land include riparian vegetation and habitat improvement, livestock grazing and watering management, and small dam construction. The smaller watershed improvement projects characterize the need for sustained management and landowner involvement in the PSCW.

In most cases large-scale projects have not been implemented in the PSCW. The focus of successful watershed improvement projects has been on localized application and landowner involvement. Large-scale watershed improvement projects like high-volume dams have not been constructed because of concerns with cost, geologic setting, and long-term maintenance.

8.0 GEOGRAPHIC INFORMATION SYSTEM DATA

The objectives of this section are to: (1) provide maps of land ownership and land use information; and (2) provide descriptions of available GIS coverages as well as any new coverages to be developed. The discussion is organized by land ownership and land use (Section 8.1) and GIS coverages (Section 8.2). `

8.1 Land Ownership and Land Use

The following discussion provides a summary of land ownership and land use in the watershed. Much of this summary is derived from the 1998 Sedimentation Study (MFG, 1998), with updated information as available.

<u>Land Ownership Information</u>

Individual private and public land ownership has been documented, over the years, by the counties of San Benito and Fresno for their respective parts of the watershed. Names, addresses, and other pertinent data on private and public landowners are available at the respective county courthouses. Aerial photographs of land parcel areas are also available at the Farm Service Agency offices in Fresno (Fresno County) and Hollister (San Benito County). For purposes of the following summary, land ownership is distinguished as public or private.

Within the watershed upstream of I-5, approximately 30 to 35 percent of the land is owned and managed by the BLM, primarily for green-season grazing. The remainder of the lands in the PSCW are privately held and managed. Figure 3 shows areas of BLM ownership in the area upstream of I-5. As shown, most of the publicly owned lands are located in the eastern half of the watershed, including Panoche Hills, the Silver Creek drainage, and Griswold Hills. The locations of BLM ownership, as illustrated on this map, are based on GIS coverages as of February 1998; which have not changed since then (Fitton, 2002).

<u>Land Use Information</u>

Land use is dictated, in large part, by the occurrence and vitality of vegetation across the watershed. Land use within the PSCW is predominantly a combination of green-season grazing and wildlife habitat. A small amount of cultivated cropland, relative to the entire watershed area, is located at the downstream end of the watershed, just upstream of I-5. Irrigated cropland continues downstream from I-5 as part of the larger San Joaquin Valley agricultural production area. Several mines have operated in the watershed, but none are currently active. Mercury mining has occurred at Idria, and seepage from this area continually provides a potential contaminant source to surface water runoff (Boyle, 1991). Gravel mining has occurred at several points along the stream downstream from the confluence of Panoche and Silver Creeks.

The PSCW is part of the San Joaquin Valley sub-region of the California Floristic Province (Hickman, 1993). Major upland vegetation types in the watershed include annual grasslands, and combinations of grassland with halfbrush, chapparal, oak, and woodland (Boyle, 1991). Annual grasslands are the predominant plant community throughout most of the watershed (UCSB, 1997); these are dominated by exotic annual grasses (*Bromus* spp., *Avena* spp., *Vulpia* spp.), exotic forbs (*Erodium* spp., *Trifolium* spp.) and native forbs (*Lupinus* spp., *Castilleja* spp.) (BLM, 1998 and BLM, 1981). Common shrub species include saltbush, allscale, or quailbush (*Atriplex* spp.). Plant community composition and production are highly variable from year to year, and are correlated with topographic location, seasonal temperature, and timing and amount of precipitation (Bartolome, et al., 1980; McNaughton, 1968; Pitt and Heady, 1978).

Conditions associated with, or resulting from, land use are summarized below – additional details are provided in the Sediment Study report (MFG, 1998). In general, grazing pressure in the upper elevations of the watershed (e.g., Bitterwater Canyon) was much less than in grazed areas in lower elevations of the watershed (e.g., Silver Creek drainage). Exceptions to this were noted in the Vallecitos area, near the confluence of San Carlos and Larious Creeks to form Silver Creek, where the upland, riparian, and some channel areas appear to be grazed heavily. During the 1998 sedimentation study (MFG, 1998), fencing in many upland areas was observed to effectively exclude or manage utilization by livestock.

A total of 16 allotments are managed by the BLM in the PSCW. Two of these allotments are located in the area surrounding the confluence of Panoche Creek and Silver Creek, and were evaluated as part of the sedimentation study (MFG, 1998) – the Silver Creek allotment (Allotment #4426) to the south and the Panoche Hills allotment (Allotment #4386) to the north. Management of the 16 allotments is focused on three primary objectives: (1) production of forage; (2) maintenance of soil cover through the dry season; and (3) protection of native saltbush (*Atriplex* spp.) for preservation of game bird habitat. Management actions designed to meet these objectives include: (1) a required residual dry matter (RDM); (2) season of use; and (3) stocking rate. Management practices that are recommended but not required for permittees include livestock class and distribution.

Adverse impacts to grazing land were noted during the 1998 sedimentation study (which focused on grazing near the Panoche-Silver Creek confluence) for the 1997-1998 grazing season. These impacts were concentrated around drainages in the majority of both upland and riparian areas of Silver Creek. Bank erosion and incised channels appeared to be correlated to trampling and heavy browsing concentrated around these numerous small drainages. Herbaceous plant cover was low to absent in some of the drainage bottoms, and adverse impacts to shrub populations (*Atriplex* spp.) were also noted. Damage to native shrubs from hedging and trampling is believed to negatively impact native game bird habitat (Cotterill, 1998; Moore, 1998). Upland slopes outside the heavily impacted areas were characterized by excellent cover, with a limited amount of erosion. In selected drainages, percent cover appeared to be excellent, allowing the drainages to function as buffers for potential sediment contribution to the nearest downstream channel.

Low vegetative cover and trampling also were noted in the riparian area of Silver Creek, and appeared more severe than the same categories of impacts occurring in upland drainages. Bank failure appeared to be related to trailing along stream banks in some areas, although in other areas bank failure appeared to be related more to soil texture. Salting locations were noted on the first terrace immediately adjacent to the stream channel, a location that may encourage trampling of erodible banks. In summary, much of the riparian vegetation along Silver Creek appeared to be heavily impacted by livestock congregation, thus contributing to bank erosion and disturbance of the native plant community.

8.2 GIS Coverages

Spatial coverages were developed and compiled in a Geographic Information System (GIS) as part of the 1998 sedimentation study (MFG, 1998). Other GIS coverages are planned for development as part of the current CALFED Grant 2000-E02 project. Existing and planned coverages are summarized below.

<u>Available (Existing) Coverages</u>

Digitized mapping information was used to delineate the watershed boundary and to develop the database that contains the various attributes of the land surface, including topography, roads, and streams. This information was obtained primarily from the BLM (MFG, 1998). Observations from the erosion feature inventory, conducted as part of the 1998 Sedimentation Study, also were entered into the GIS database. Vegetation mapping information for the PSCW area was obtained from the internet website at University of California, Santa Barbara (UCSB, 1997), as developed for the "Gap Analysis Program" (GAP). A listing of GIS coverages utilized for the 1998 sedimentation study is provided in Appendix A.

In addition to digitized data imported from various outside sources, several layers of data were developed for the hydrologic characterization of the watershed. Hydrologic basin-specific delineations (sub-basins) were digitized from Boyle (1992) and incorporated into the GIS. A total of 40 sub-basins from Boyle (1992) were delineated, and additional subdivisions were made for sub-basins in the lower watershed for the 1998 sedimentation study, to yield a total of 49 sub-basins.

GIS coverages obtained or developed as part of the 1998 Sedimentation Study (MFG, 1998) are listed below. Area, region, and image coverages include:

- USGS 1:24000 and 1:100,000 scale topographic map boundaries
- USGS 1:24000,1:100,000 and 1:250,000 Digital Raster Graphs (DRG), scanned and GIS ready topographic maps
- 30-meter Digital Elevation Model (DEM) data for USGS 7.5 minute quad sheets
- Black and white and color infrared satellite images of PSCW and nearby regions
- Shaded relief map of PSCW and surrounding area
- Shaded relief image derived from 30-meter DEMs
- Township and range reference boundaries
- BLM and public land ownership boundaries
- California state and county boundaries, all counties
- Study area boundary
- Upper and lower PSCW boundaries
- First and second order watershed boundaries of PSCW and nearby regions
- PSCW subbasin boundaries including AGNPS parameters used for subbasin delineation
- Partial bedrock geology and surface deposits within PSCW
- Regional coded soil survey boundaries, partial coverage of PSCW
- Stream incision data developed by William Lettis & Associates
- Erosion feature and classification boundaries, developed from Spring 1998 field observations

- Vegetation type polygons delineated by common name, developed by GAP analysis program

Point and line coverages include:

- 40 foot contour lines derived from 30-meter DEMs
- 100 foot contour lines derived from 30-meter DEMs
- 1:100,000 scale Digital Line Graphs (DLG) of road data in PSCW and surrounding region
- 1:100,000 scale DLG of stream course data in PSCW and surrounding region
- Center points for most current air photos, partial coverage of PSCW
- GPS data from Spring 1998 field erosion inventory observations
- GPS data from Spring 1998 including riparian area survey points

Planned Coverages (to be Developed)

As part of the current CALFED project (2000-E02) work, additional GIS coverages are planned. These would include, but are not necessarily limited to, the following:

1. Monitoring locations for BMPs;
2. Rainfall monitoring locations;
3. Streamflow monitoring locations;
4. Water quality monitoring locations;
5. Soil survey information from the NRCS Western Fresno County Soil Survey (currently in finalization under the perview of Kerry Arroues of NRCS, Hanford, California); and
6. Digitized geologic map of PSCW with units and formations compiled from California DMG 1:250,000 Santa Cruz Sheet (CDMG, 1959) and USGS 1:50,000 Map I-2430 (Bartow, 1996) and USGS 1:62,500 15 minute quadrange maps (Dibblee, 1971).

These additional coverages will be used for evaluation of monitoring data, analysis of watershed characteristics, and presentation of results in the final product of the CALFED grant project work – the Panoche/Silver Creek Watershed Management and Action Plan (PSCW MAP).

9.0 REFERENCES

In addition to the references cited in this document, as listed below, the Panoche-Silver Creek Literature Review and Technical Summary (NRCS, 1998) provides a more thorough summary of existing literature and an annotated bibliography for Panoche-Silver Creek studies. A listing of references, including those provided by the NRCS (1998) is provided in Appendix B.

Arroues K., 2002. NRCS Soil Survey for Western Fresno County is in press at the date of this technical memorandum.

Bartolome, J.W., M.C. Stroud, and H. Heady, 1980. Influence of natural mulch on forage production on differing California annual range sites. Journal of Range Management 33(1) pp. 4-8.

Bartow, J.A., 1996. Geologic map of the west border of the San Joaquin Valley in the Panoche Creek-Cantua Creek area, Fresno and San Benito Counties, California: U.S. Geological Survey Miscellaneous Investigations Series I-2430, scale 1:50,000.

Boyle Engineering Corporation (Boyle), 1991. Preliminary draft letter report - evaluation of general resource conditions, Panoche/Silver Creek Watershed Management Plan. Sacramento, California. August.

Boyle, 1992a. Preliminary draft letter report - development and application of hydrologic model, Panoche/Silver Creek Watershed Management Plan. Sacramento, California. December.

Boyle, 1992b

Bureau of Land Management, U.S. Department of the Interior (BLM), 1981. Panoche Hills management plan - draft environmental assessment. Hollister, California. December.

BLM, 1998. Rangeland health standards and guidelines for California and northwestern Nevada, final environmental impact statement.

CDMG, 1959. Geologic Map of California Santa Cruz Sheet. scale 1:250,000

Corps of Engineers, 1994. *Office Report, Reconnaissance Study Hydrology, Cities of Firebaugh and Mendota, California.* October.

Corps of Engineers, 1995., *Reconnaissance Report, Firebaugh and Mendota, San Joaquin River Basin, California.* June.

Cotterill, B, 1998. Personal communication. March-June.

Dibblee, T.W., 1971, Geologic maps of seventeen 15-minute quadrangles (1:62,500) along the San Andreas fault in the vicinity of King City, Coalinga, Panoche Valley, and Paso Robles, California. U.S. Geological Survey Open-File Report OF-71-87, scale 1:62,500.

Department of Water Resources, San Joaquin District, State of California, 1987 . *Draft Report, Panoche-Silver Creek Flood Frequency Analysis.* December.

Fitton, S. 2002. Personal communication on June 11, 2002.

Freeman, L. 2001. Personal communication on September 26, 2001.

Gilliom, R.J., 1989. Preliminary Assessment of Sources, Distribution, and Mobility of Selenium in the San Joaquin Valley, California. USGS Water-Resources Investigations Report 88-4186.

Hickman, J.C., ed., 1993. The Jepson manual: higher plants of California. University of California Press, Ltd. London, England.

McNaughton, S.J., 1968. Structure and function of California grasslands. Ecology 49 (5)pp. 962-972.

MFG, Inc., 1998. *Panoche/Silver Creek Watershed Assessment Final Report*. Panoche/Silver Creek Watershed Coordinated Resource Management and Planning Group (CRMP) and the City of Mendota. September.

MFG, Inc., 2001. *Economic and Conservation Benefits Analysis of Sediment Control Best Management Practices in the Panoche/Silver Creek Watershed Final Report*. Packard Foundation Grant Project. September.

Moore, T., 1998. Personal communication. April-June.

NRCS, 1997. Panoche-Silver Creek Literature Review and Technical Summary

North State Resources, Inc., Stetson Engineers, Inc., Merritt Smith Consulting, and Alex Horne Associates, 1999. *Panoche Creek Corridor Project Feasibility Study – Draft Report*. Authorized by the U.S. Bureau of Reclamation. February.

Pitt, M.D. and H.F. Heady, 1978. Responses of annual vegetation to temperature and rainfall patterns in northern California. Ecology 59(2): 336-350.

Presser, T.S., et al., 1990, *Geologic Sources, Mobilization, and Transport of Selenium from the California Coast Ranges to the Western San Joaquin Valley: A Reconnaissance Study.* U.S. Geological Survey.

Summers Engineering, Inc., 1998. *Panoche/Silver Creek Erosion and Flood Control Proposal for Mendota and Surrounding Agricultural Areas.* Prepared for City of Mendota, Panoche Creek Coordinated Resource Management and Planning Group (CRMP), and the Silver Creek Drainage District.

University of California, Santa Barbara (UCSB), 1997. Gap analysis program (GAP), UCSB Biogeography Laboratory ftp://lorax.geog.ucsb.edu/pub/data/gap-analysis

U.S. Geological Survey (USGS), 2001a. Streamflow measurements and water quality data for USGS gages #11255500 and #11255575 per http://water.usgs.gov/nwis.

U.S. Geological Survey (USGS), 2001b. Techniques of Water-Resources Investigations (TWRIs) of the USGS. Internet site http://oregon.usgs.gov/pubs_dir/twri-list.html.

Westside Resource Conservation District (WRCD), 2000. Panoche/Silver Creek watershed management and action plan – work plan. CALFED Grant 2000-E02. October 2000.

TABLES

Table 1. Summary of USGS Streamflow and Water Quality Data Available for the Panoche/Silver Creek Watershed

USGS Gaging Station	USGS Gage I.D.	Data Available	Period of Record
Panoche Crk blw Silver Crk nr Panoche CA	11255500	Annual peak flows	18-Sep-50 through 11-Feb-73
Panoche Crk blw Silver Crk nr Panoche CA	11255500	Daily flows	01-Oct-49 through 30-Sep-70
Panoche Crk blw Silver Crk nr Panoche CA	11255500	Water Quality Samples	17-Nov-65 through 24-Jan-67 [1]
Panoche Crk at I-5 nr Silver Creek CA	11255575	Annual peak flows	03-Feb-98 through through 23-Feb-00
Panoche Crk at I-5 nr Silver Creek CA	11255575	Daily flows	01-Dec-97 through 30-Jun-00 [2]
Panoche Crk at I-5 nr Silver Creek CA	11255575	Water Quality Samples	19-Jan-98 through 08-Apr-99 [3]

Notes:

[1] Six water quality samples were collected for suspended sediment size distribution analyses during period of record.

[2] Real-time data is also available for this gaging station at http://water.usgs.gov/nwis/discharge

[1] 69 water quality samples were collected during period of record.

Table 2. Panoche Creek Sediment and Selenium Measurements at USGS Gaging Stations

DATE	TIME	FLOW (CFS)	SUSPENDED SEDIMENT (mg/L)	PERCENT FINER THAN 0.062 mm	DISSOLVED SELENIUM (µg/L)	SEDIMENT-SELENIUM [1] (µg/L)	TOTAL SELENIUM (µg/L)
17-Nov-65	13:30	5	18,500	nm	nm	nm	nm
18-Nov-65	14:00	1.3	12,800	100	nm	nm	nm
24-Nov-65	13:15	21	19,800	nm	nm	nm	nm
24-Nov-65	14:45	17	20,000	100	nm	nm	nm
08-Dec-65	8:45	3.4	1,310	nm	nm	nm	nm
24-Jan-67	13:10	108	38,900	nm	nm	nm	nm
19-Jan-98	13:50	38	20,200	90	nm	nm	nm
30-Jan-98	12:00	4.5	nm	nm	11	nm	12
30-Jan-98	12:15	4.3	1,480	66	nm	nm	nm
02-Feb-98	9:20	122	24,900	85	nm	nm	nm
02-Feb-98	9:30	188[4]	23,100	88	6.5	14	21
02-Feb-98	10:10	122	nm	nm	6.8	n/a[2]	4.7
02-Feb-98	12:30	nm	17,900	85	4.9	12	17
02-Feb-98	12:40	85	18,300	78	nm	nm	nm
03-Feb-98	3:00	*228*	54,400	70	16	71	87
03-Feb-98	7:00	*3,860*	140,000	71	26	294	320
03-Feb-98	10:30	*9,530*	177,000	60	30	260	290
03-Feb-98	12:00	*6,840*	230,000	48	56	204	260
03-Feb-98	14:00	*3,920*	229,000	48	60	190	250
03-Feb-98	16:00	*2,420*	177,000	53	50	150	200
03-Feb-98	19:00	*1,250*	131,000	58	46	114	160
04-Feb-98	23:59	*517*	86,400	60	25	85	110
04-Feb-98	7:00	*263*	63,900	70	24	86	110
04-Feb-98	11:45	149	37,000	72	nm	nm	nm
06-Feb-98	11:40	*1,500*	251,000	47	38	222	260
06-Feb-98	12:40	*2,420*	157,000	58	37	93	130
06-Feb-98	13:40	*2,120*	163,000	60	32	168	200
06-Feb-98	15:30	*1,750*	136,000	52	32	88	120
06-Feb-98	18:30	*874*	129,000	52	30	65	95
06-Feb-98	22:30	*677*	122,000	47	30	80	110
07-Feb-98	3:30	*454*	90,300	60	22	65	87
07-Feb-98	9:30	*177*	48,700	65	25	48	73
12-Feb-98	17:00	55	13,000	72	nm	nm	nm
21-Feb-98	16:40	*48*	32,900	31	30	27	57
21-Feb-98	22:40	*660*	150,000	56	44	146	190
21-Feb-98	23:40	*952*	135,000	56	32	108	140
22-Feb-98	0:40	*829*	116,000	57	25	75	100
22-Feb-98	2:40	*484*	86,900	63	29	71	100
22-Feb-98	5:40	*257*	54,500	71	20	62	82
22-Feb-98	8:40	*180*	51,500	61	20	62	82
22-Feb-98	12:30	*182*	42,000	65	24	62	86
23-Feb-98	15:40	*367*	94,500	52	30.	80	110.
23-Feb-98	16:30	*1390*	150,000	52	31	89	120
23-Feb-98	17:10	*1740*	152,000	52	26	94	120
23-Feb-98	21:00	*458*	106,000	59	21	99	120
24-Feb-98	6:30	*169*	52,700	43	21	52	73
03-Apr-98	13:10	21	nm	nm	18	10	28
03-Apr-98	14:45	21	6,530	66	nm	nm	nm
06-Apr-98	16:30	21	7,920	74	nm	nm	nm
14-Apr-98	12:45	18	nm	nm	19	10	29
14-Apr-98	15:25	18	10,800	74	nm	nm	nm
28-Apr-98	11:30	2.4	3,360	96	nm	nm	nm
12-May-98	13:50	9.5	12,000	82	nm	nm	nm
03-Jun-98	12:15	1.1	5,510	97	nm	nm	nm
01-Jul-98	15:08	2.8	12,500	88	nm	nm	nm
08-Apr-99	13:15	0.5	nm	nm	<1	<1	1
08-Apr-99	14:00	0.3	2,770	100	nm	nm	nm

Notes:

1965 and 1967 data collected at Panoche Creek blw Silver Crk nr Panoche CA (USGS gage #11255500)
1998 and 1999 data collected at Panoche Creek at I-5 near Silver Creek, CA (USGS gage #11255575)
nm - not measured or not reported in USGS records.
italicized values are flow measurements per North States et. al, 1999 but not published by USGS
[1] Sediment-Selenium was not directly measured, it was calculated as the difference between Total Selenium and Dissolved Selenium.
[2] Not applicable due to questionable measurement (total selenium is less than dissolved selenium).

FIGURES

Appendix A
Geographic Information System (GIS) Coverages for the Panoche/Silver Creek Watershed

Appendix A
Geographic Information System (GIS) Coverages for the Panoche/Silver Creek Watershed

Coverages from CRMP:

AIRPHO - airphoto center points for most current airphoto coverage, but not all historic airphoto points
CLIP - (MFG) project clipping boundary
CON75 - 40 foot contours derived from 7.5 minute dems
G10P019 - USGS 100k map boundaries
G24P019 - USGS 24k map boundaries
GEOPAYSC - Bedrock geology polys for mineral bearing strata
GRZP019 - Bedrock geology polys for mineral bearing strata
HYDP019 - First and second order watershed boundaries
OWNP019 - BLM surface estate polys
POURPNT - (MFG) model outlet (point)
PSLP019 - Public land survey polys
RDSLAHCO - 100k DLG trans for ah36120 sma
RDSLAHPS - 100k DLG trans for ah36121 sma
RDSLEHME - 100k DLG trans for eh36120 sma
RDSLEHMO - 100k DLG trans for eh36121 sma
SLSP019 - Mixed order soil survey polygons
STRLAHCO - 100k DLG hydro for ah36120 sma
STRLAYSC - 100k DLG hydro for 1:250k Santa Cruz sheet
STRLEHME - 100k DLG hydro for eh36120 sma
STRLEHMO - 100k DLG hydro for eh36121 sma
SUBBASIN - (MFG) subbasin boundaries and AGNPS parameters for subbasins
TRP019 - Township and range reference polygons
VEGP019 - Centralized vegetation polys
WSBUF - Watershed boundary (buffered) from Boyle? Report FRED?
WSHED - Watershed boundaries from Boyle? report
WSLOWER - (MFG) Lower watershed boundary
WSUPPER - (MFG) Lower watershed boundary

DEM - 7.5 minute (30-meter) digital elevation model for quads:
D536120DEM D636120DEM D736120DEM D836120DEM E536120DEM E636120DEM
E736120DEM E836120DEM F636120DEM F736120DEM F836120DEM

All coverages have the following projection:

Projection	UTM
Zone	10
Datum	NAD27
Zunits	METERS
Units	METERS
Spheroid	CLARKE1866

MFG developed Arc/Info coverages:

COUNTY - Fresno/San Benito County line near study area (arcs, annotation)
ERO98PNT - Point Erosion features from Spring 1998 FLC field observation (point)
ERO98POL - Polygon Erosion features from Spring 1998 FLC field observation (polygon)
EROANNO - Annotation for point and polygon erosion features from Spring 1998 FLC field observation (annotation)
GPS12 - Raw GPS data from Spring 1998 FLC field observation (point) may need WGS84 adjustment...
INCISION - Stream incision area in lower watershed
PANOUTM - Maria Sonett GPS data (WGS84?)
RIPARDD -
RIPARUTM - Riparian area survey points from Maria Sonett Spring 1998
STUDAREA - Study area boundary

GAP analysis vegetation coverages:

CWVEGU - Central Western Region
GVVEGU - Great Valley Region

SOURCE DATA:
POLYGON BOUNDARIES WERE DERIVED FROM PHOTOINTERPRETATION OF 1990 LANDSAT THEMATIC MAPPER DIGITAL IMAGES, SUPPLEMENTED BY 1990 HAP PHOTOGRAPHY AND LARGE SCALE VEGETATION MAPS.

ATTRIBUTE DATA CAME FROM THE 1990 HAP PHOTOGRAPHY, THE 1930's VTM SURVEY MAPS (i.e. WIESLANDER), FIELD VISITS, AND LARGE SCALE VEGETATION MAPS.

AUTOMATION SCALE: 1:100,000

Appendix B
Expanded Reference List

Appendix B
Expanded Reference List

Author	Date	Title	Publisher
Bartow, Alan J	1996	Geologic Map of the West Border of the San Joaquin	USGS Miscellaneous Investigations Series I-2430
Belitz, K., Philips, S., Dubrovsky, N.	1999	Development of a Transient, Three-Dimensional Groundwater Flow Model for the Grasslands and Adjacent Areas of Western San Joaquin Valley	
Beyer, John	1997	Panoche Silver Creek Watershed Project	California Watershed Projects Inventory
Boyle Engineering Corporation	1992	Development and Application of Hydrologic Model, Panoche/Silver Creek Watershed Management Plan, Preliminary Draft Letter Report, submitted to Bureau of Reclamation	Boyle Engineering Corporation
Boyle Engineering Corporation	1988	Silver Creek and Panoche Creek Drainage, Sediment and Water Quality Control Master Plan - Work Plan	Boyle Engineering Corporation
Boyle Engineering Corporation	1992	Review of Existing Water Quality Information, Panoche/Silver Creek Watershed Management Plan, Preliminary Draft Letter Report, submitted to Bureau of Reclamation	Boyle Engineering Corporation
Boyle Engineering Corporation	1986	Evaluation of On-Farm Agricultural Management Alternatives	Boyle Engineering Corporation
Boyle Engineering Corporation	1989	Draft Letter Report: Review of Existing Data Related to the Silver-Panoche Creek Watershed and Drainage Master Plan	Boyle Engineering Corporation
Boyle Engineering Corporation	1992	Development and Application of Hydraulic Model, Panoche/Silver Creek Watershed Management Plan, Preliminary Draft Letter Report, submitted to Bureau of Reclamation	Boyle Engineering Corporation
Boyle Engineering Corporation	1991	Evaluation of General Resource Conditions, Panoche/Silver Creek Watershed Management Plan, Preliminary Draft Letter Report, submitted to Bureau of Reclamation	Boyle Engineering Corporation
Bradley, Steven	1997	Personal Communication	
Bull, W.B.	1972	Prehistoric Near-Surface Subsidence Cracks in Western Fresno County, California	USGS Profesional Paper 437-C
Bull, W.B.	1961	Causes and mechanics of near-surface subsidence in western	Short Papers in the Geologic and

Author	Date	Title	Publisher
		Fresno County, California	Hydrologic Sciences, Articles 1-146: B-187--B-189
Bull, William B.	1964	Alluvial Fans and Near-Surface Subsidence in Western Fresno County California	USGS Professional Paper 437-A
Bull, William B.	1964	Geomorphology of Segmented Alluvial Fans in Western Fresno County, California; Erosion and Sedimentation in Semiarid Environment	USGS Professional Paper 352-E
California Department of Fish and Game	1994	Selenium Monitoring and Evaluation Program: A Report to the California State Water Resources Control Board, 1991	State of California, The Resources Agency, Department of Fish and Game, Bay-Delta and Special Water Projects Division
California DMG	1959	Geologic Map of California Santa Cruz Sheet	California DMG
California Regional Water Quality Control Board, Central Valley Region	1991	Preliminary Estimate of Salt and Trace Element Loading to the San Joaquin River by Ephemeral Streams Draining to the Eastern Slope of the Coast Range (Diablo Range)	California Regional Water Quality Control Board, Central Valley Region
California, Department of Water Resources Division of Planning State of California The Resources Agency	1983	Rating Watershed Health or Condition: Literature Review	State of California, The Resources Agency, Department of Water Resources, Division of Planning
California, Department of Water Resources San Joaquin District	1987	Panoche - Silver Creek Flood Frequency Analysis	DWR
City of Mendota	1997	Panoche/Silver Creek 205 (j) Watershed Assessment Work Plan	City of Mendota
Common Ground, Center for Cooperative Solutions University Extension University of California Davis.	1995	The Central Coast Sustainable Landscapes Project	Common Ground, Center for Cooperative Solutions, University Extension, University of California, Davis.
Crawford, Norman H.	1978	Panoche Creek Flooding	unknown
Deverel, S. J.; Gilliom, R. J.;Fujii, Roger ;Izbicki, J. A.; Fields, J. C.	1984	Areal Distribution of Selenium and Other Inorganic Constituents in Shallow Ground Water: A Preliminary Study; Intradepartmental Drainage Study Program, Western San Joaquin Valley, California	USGS Water-Resources Investigations Report 84-4319
Dibblee, Jr. T. W.	1975	Geologic Map of the Panoche Valley Quadrangle, California	USGS Open File Report (OFR-75-394)
Dibblee, T.W.	1971	Geologic Maps of seventeen 15-minute quadrangles (1:62,500) along the San Andreas Fault in the vicinity of King City, Coalinga,	USGS OFR OF-71-87

Author	Date	Title	Publisher
		Panoche Valley, and Paso Robles, California.	
DWR	1995	Water Quality Assessment of Floodwater Inflows in the San Luis Canal, California Aqueduct	DWR
Enos, Paul	1965	Geology of the Western Vallecitos Syncline, San Benito County, California	Division of Mines and Geology
Frankenberger, W.T., Benson, S.	1994	Selenium in the Environment	Marcel Dekker Inc., New York, New York
Fullen, Karen	1994	Inventory of Resources in the Panoche/Silver Creek Watershed	USDA Soil Conservation Service Report submitted to U.S. EPA
Geomatrix Consultants	1989	Phase I Final Report: Stratigraphy and Groundwater Quality of Selected Areas of the Lower Panoche Fan, Western San Joaquin Valley, California	Geomatrix Consultants, Inc.
Geomatrix Consultants	1991	Phase III Final Report: Hydrogeologic Model, Panoche Fan Groundwater Project,, Western San Joaquin Valley, California	Geomatrix Consultants, Inc.
Geomatrix Consultants	1990	Phase II Final Report: Stratigraphy and Groundwater Quality of Selected Areas of the Lower Panoche Fan, Western San Joaquin Valley, California	Geomatrix Consultants, Inc.
Harza Consulting Engineers and Scientists	1994	Field Report on the Impacts of Flooding of San Joaquin River System (San Joaquin River/Mendota Pool/Fresno Slough), Including Cities of Firebaugh and Mendota	Harza Consulting Engineers and Scientists
Harza Consulting Engineers and Scientists//US Army Corps of Engineers	1995	DRAFT Firebaugh and Mendota Reconnaissance Study, Basis of Design and Cost Estimates: Collection and Evaluation of Data on Flooding of the San Joaquin River System	Harza Consulting Engineers and Scientists
Hirsch, R.M., Walker, J.F., Day, J.C., Kallio, R.	1990	The Influence of man on Hydrologic Systems	Surface Water Hydrology: Boulder Colorado, Geological Society of America, The Geology of North America v. O-1
Ireland, R. L	1986	Land Subsidence in the San Joaquin Valley, California, as of 1983	USGS Water-Resources Investigations Report 85-4196
Ireland, R. L.; Poland, J. F.; Riley, F. S.	1984	Land Subsidence in the San Joaquin Valley, California, as of 1980	USDA NRCS
Laudon, Julie; Belitz, Kenneth	1991	Texture and Depositional History of	Bulletin of the

Author	Date	Title	Publisher
		Late Pleistocene-Holocene Alluvium in the Central Part of the Western San Joaquin Valley, California	Association of Engineering Geologists, XXVIII, v. 1, pg 73-88
Leighton, David A.; Fio, John L	1995	Evaluation of a Monitoring Program for Assessing the Effects of Management Practices on the Quantity and Quality of Drainwater from the Panoche Water District, Western San Joaquin Valley ,CA	USGS Open-File Report 95-731
Leonard, Steve; Staidl, George; Fogg, Jim; Gebhardt, Karl; Hagenbuck, Warren; Prichard, Don	1992	Riparian Area Management: Procedures for Ecological Site Inventory -- With Special Reference to Riparian-Wetland Sites	BLM Technical Reference 1737-7
Mount, Jeffrey F.	1995	California Rivers and Streams, The Conflict Between Fluvial Process and Land Use	University of California Press
NRCS	1997	Annotated Bibliography for Panoche/Silver Creek Literature Review.	NRCS
NRCS, Meyer, Robyn	1997	Panoche-Silver Creek Literature Review and Technical Summary	NRCS
Pacific Southwest Inter-Agency Committee	1968	Report of the Water Management Subcommittee	Pacific Southwest Inter-Agency Committee
Pafford, Jr. R. J.	1963	Interim Report on Geologic Investigations (February-July 1963) for Panoche Creek Dam, Central Valley Project, California, San Luis Unit	USDI Bureau of Reclamation
Poland, J. F.; Lofgren, B. E.; Ireland, R. L.; Pugh, R. G.	1975	Land Subsidence in the San Joaquin Valley, California, as of 1972	USGS Professional Paper 437-H
Presser, T. S	1994	"The Kesterson Effect"	Environmental Management Vol. 18, No. 3, pp. 437-454
Presser, T. S., Ohlendorf, H. M.	1987	Biogeochemical Cycling of Selenium in the San Joaquin Valley, California, USA	Environmental Management Vol. 11, No. 6, pp. 805-821
Presser, T. S.; Swain, W. C.; Tidball, R. R.	1988	Reconnaissance of the Drainage Basins of the Coast Regions of California that Impact on the Selenium Contamination of the Western San Joaquin Valley	USGS
Presser, T.S., Swain, W.C.	1990	Geochemical evidence for Se mobilization by the weathering of pyritic shale, San Joaquin Valley, California, U.S.A.	Applied Geochemistry 5: 703-717
Presser, T.S., Sylvester, M.A., Low, W.H.	1994	"Bioaccumulation of Selenium from Natural Geologic Sources in Western States and Its Potential Consequence	Environmental Management Vol. 18, No. 3, pp. 423-436
Presser, Theresa S.; Swain, Walter C.; Tidball, Ronald R.; Severson, R.	1990	Geologic Sources, Mobilization, and Transport of Selenium from the	U.S. Geological Survey, Water-Resources

Author	Date	Title	Publisher
C.		California Coast Ranges to the Western San Joaquin Valley: A Reconnaissance Study	Investigations Report 90-4070
Prokopovich, Nicola P.	1986	Origin of Vertical Clearage in Piedmont Alluvium, West-Central San Joaquin Valley, California	California Geology
Prokopovich, Nicola P.	1980	Memorandum	
PSCW CRMP - Panoche Silver Creek Watershed Coordinated Resource Management Planning Group	1991	Panoche/Silver Creek Watershed Management Plan	PSCW CRMP
Read, Hershel R	1996	Letter to Gerald R. Stoltenberg	
Renning, John A.	1977	Determination of Flood Areas for 1/100, 1/50, 1/25, 1/10 Exceedance Frequency Floods on Panoche Creek near Mendota, California (Memorandum)	U.S. Army Corps of Engineers
Rivera, Romeo//USDA - River Basin Planning Staff	1973	Panoche-Silver Creek Watershed Investigation, VDP Study, Fresno-San Benito Counties, California "Bridging the Gap Between Theory and Practice"	Fresno-San Benito Counties
Summers Engineering, Inc.	1998	Panoche/Silver Creek Erosion and Flood Control Proposal for Mendota and Surrounding Agricultural Areas	Summers Engineering, Inc.
Summers Engineers	1959	Doug White Ranch	Summers Engineers
U.C. Davis	2001	Watershed Projects Inventory (WPI)	
US Army Corps of Engineers	1995	Environmental Evaluation: Firebaugh and Mendota, California, Flood Control Reconnaissance Study	U.S. Army Corps of Engineers
US Army Corps of Engineers, Sacramento District	1995	DRAFT Planning Aid Report for the Firebaugh/Mendota, California Flood Control Reconnaissance Study	U.S. Army Corps of Engineers
US Army Corps of Engineers, Sacramento District	1994	Reconnaissance Study, Hydrology, Cities of Firebaugh and Mendota, California	U.S. Army Corps of Engineers
US Army Corps of Engineers, Sacramento District Economics Branch	1995	Reconnaissance Study, Economic Analysis, Firebaugh and Mendota, California	U.S. Army Corps of Engineers
US Army Corps of Engineers, Sacramento District South Pacific Division	1995	Reconnaissance Report, Firebaugh and Mendota, San Joaquin River Basin, California	U.S. Army Corps of Engineers
US Army Corps of Engineers, Sacramento District South Pacific Division	1995	Reconnaissance Report, Appendixes A-D, Firebaugh and Mendota, San Joaquin River Basin, California	U.S. Army Corps of Engineers
USDA - River Basin Planning Staff	1987	Westside Stream Group, Panoche-Silver Creek Unit, Draft Salinity Report	USDA - River Basin Planning Staff, Soil Conservation Service,

Author	Date	Title	Publisher
			Forest Service
USDA - River Basin Planning Staff	1977	San Joaquin Valley Basin Study	USDA- SCS and the California Department of Water Resources
USDA - River Basin Planning Staff	1989	Westside Stream Group, Panoche Creek Salinity Study, Fresno County, CA: A part of California Special Studies, Basin and Area Planning: Final Report	USDA, River Basin Planning Staff, Soil Conservation Service, Forest Service
USDA - Soil Conservation Service	1976	Three Volumes of Back-up Data for the Watershed Investigation of Panoche-Silver Creek	USDA - Soil Conservation Service
USDA - Soil Conservation Service	1977	Panoche-Silver WIR Folders: Misc. Documents (Letters, Memos, and other documentation)	USDA - Soil Conservation Service
USDA - Soil Conservation Service	1983	Draft Field Examination Report, Panoche-Broadview-Grasslands Watershed, Fresno/Merced Counties, California	USDA - Soil Conservation Service
USDA - Soil Conservation Service	1989	Field Review Report: Westside Stream Group - Cantua, Salt, and Hondo Creeks, Fresno County, California	USDA - Soil Conservation Service
USDA - Soil Conservation Service	1994	Hydrologic Unit Planning Team Report, Westside Stream Group, Panoche-Silver Creek Watershed, Fresno-San Benito Counties, California	USDA - Soil Conservation Service
USDA - Soil Conservation Service	1989	Panoche Creek Salinity Study - Report Summary	USDA - Soil Conservation Service
USDA - Soil Conservation Service	1956	Soil Survey, Mendota Area, California, Series 1940, No. 18	USDA - Soil Conservation Service
USDA - Soil Conservation Service	1969	Soil Survey, San Benito County	USDA - Soil Conservation Service
USDA - Soil Conservation Service	1988	Soil Survey, Western Fresno County	USDA - Soil Conservation Service
USDA - Soil Conservation Service	1993	Inventory of Resources in the Panoche/Silver Creek Watershed	USDA - Soil Conservation Service
USDA - Soil Conservation Service	1976	Watershed Investigation Report, Panoche-Silver Creek Watershed, Fresno and San Benito Counties, California: The San Joaquin Valley Basin USDA River Basin Study	USDA - Soil Conservation Service
USDA - Soil Conservation Service	1973	Watershed Investigation Report, on Panoche-Broadview, Merced and Fresno Counties, California	USDA - Soil Conservation Service
USDI - Bureau of Reclamation	1978	Panoche creek and San Luis Unit Central Valley Project Potential Flooding Volume I and II Special Report	USDI - Bureau of Reclamation
USDI - Bureau of Reclamation	1987	Water Quality Analysis West Side -	USDI - Bureau of

Author	Date	Title	Publisher
		San Joaquin Valley	Reclamation
USDI - Bureau of Reclamation	1981	Three binders of background engineering data for both Panoche Creek Flood Protection Works and for Panoche Creek San Luis Unit Central Valley Project Potential Flooding Volumes I and II, Special Report	USDI - Bureau of Reclamation
USDI - Bureau of Reclamation	1981	Panoche Creek Flood Protection Works: San Luis Unit, West San Joaquin Division, Central Valley Project, California: SPECIAL REPORT	USDI - Bureau of Reclamation
USDI - Bureau of Reclamation	1963	Interim Report of Geologic Investigations for Panoche Creek Dam - Central Valley Project, California, San Luis Unit	USDI - Bureau of Reclamation
USDI - Bureau of Reclamation	1984	Arroyo Pasajero Flood and Silt Deposition Study: Special Report on Flood Protection for San Luis Canal	USDI - Bureau of Reclamation
USDI - Bureau of Reclamation	1978	Panoche Creek, San Luis Unit, Central Valley Project: Potential Flooding, Volume 1, Special Report	USDI - Bureau of Reclamation
USDI - Bureau of Reclamation//USGS - U.S. Geological Survey//U.S. Fish and Wildlife Service//California, Department of Water Resources San Joaquin District//California Department of Fish and Game	1990	A Management Plan for Agricultural Subsurface Drainage and Related Problems on the Westside San Joaquin Valley: FINAL REPORT of the San Joaquin Valley Drainage Program	USDI - Bureau of Reclamation
USDI BLM - Bureau of Land Management, Bakersfield District	1981	Panoche Hills Management Plan, Draft Environmental Assessment: Panoche Hills, Ciervo Hills, Tumey Hills, Griswold Hills, Fresno and San Benito Counties, California	USDI BLM
USDI BLM - Bureau of Land Management, Bakersfield District	1984	Hollister Resource Management Plan and Record of Decision	USDI BLM
USDI BLM - Bureau of Land Management, Bakersfield District	1987	Management Plan for the Panoche/Coalinga Area of Critical Environmental Concern	USDI BLM
USFWS - United States Department of the Interior Fish and Wildlife Service	1995	DRAFT: Planing Aid Report for the Firebaugh/Mendota, California Flood Control Reconnaissance Study	USFWS
USGS - U.S. Geological Survey	1989	Preliminary Assessment of Sources, Distribution and Mobility of Selenium in the San Joaquin Valley, CA, Water-Resources Investigations Report 88-4286,	USGS
USGS- U.S. Geological Survey	1972	Land Subsidence due to Ground-Water Withdrawal in the Los Banos-Kettleman City Area, California	USGS OFR ???
Woodward-Clyde Consultants	1994	Groundwater Study of Mendota Pool	Woodward-Clyde

Author	Date	Title	Publisher
		and Vicinity	Consultants